PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 19 April 2000 (19.04.00)	
International application No. PCT/EP99/00425	**Applicant's or agent's file reference** 300K PCT 362
International filing date (day/month/year) 25 January 1999 (25.01.99)	**Priority date** (day/month/year) 25 August 1998 (25.08.98)
Applicant PIRIM, Patrick et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

16 March 2000 (16.03.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Claudio Borton
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION** see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
300K PCT 362		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/EP 99/ 00425	25/01/1999	25/08/1998
Applicant		
HOLDING B.E.V. SA et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 15A, B

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [X] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 99/00425

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G06T7/00 G06K9/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G06T G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 0 380 659 A (KABUSHIKI KAISHA KOMATSU SEISAKUSHO) 8 August 1990 see claims 1,3,4	79 1,33
Y	EP 0 394 959 A (FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.) 31 October 1990 see abstract	1,4,21, 33,37,53

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 May 1999	28/05/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Chateau, J-P

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Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	YAMADA K ET AL: "IMAGE UNDERSTANDING BASED ON EDGE HISTOGRAM METHOD FOR REAR-END COLLISION AVOIDANCE SYSTEM" PROCEEDINGS OF THE VEHICLE NAVIGATION AND INFORMATION SYSTEMS CONFERENCE, YOKOHAMA, AUG. 31 - SEPT. 2, 1994,31 August 1994, pages 445-450, XP000641348 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS see page 446, right-hand column, paragraph 3; figure 3	24,56,83
Y		4,21,37, 53
A		65,69, 71,72

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 99/00425

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 380659 A	08-08-1990	WO 8903094 A	06-04-1989
		US 5181258 A	19-01-1993
EP 394959 A	31-10-1990	DE 3913620 A	31-10-1990
		DE 59010833 D	13-08-1998

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
300K PCT 362		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/00425	25/01/1999	25/08/1998
International Patent Classification (IPC) or national classification and IPC G06T7/00		
Applicant HOLDING B.E.V. SA et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 11 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
16/03/2000	29.11.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Müller, M Telephone No. +49 89 2399 7409

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/00425

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1-53	as originally filed				

Claims, No.:

1-37	as received on	24/08/2000	with letter of	22/08/2000	

Drawings, sheets:

1-16	as originally filed				

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   ☐ the language of publication of the international application (under Rule 48.3(b)).
   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.
   ☐ filed together with the international application in computer readable form.
   ☐ furnished subsequently to this Authority in written form.
   ☐ furnished subsequently to this Authority in computer readable form.
   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:
   ☒ the claims, Nos.: 38-91

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-37
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-37 (if clarified)
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-37
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Citations

Reference is made to the following documents:

D1: EP-A-0 380 659 (KABUSHIKI KAISHA KOMATSU SEISAKUSHO) 8 August 1990

D2: YAMADA K ET AL: 'IMAGE UNDERSTANDING BASED ON EDGE HISTOGRAM METHOD FOR REAR-END COLLISION AVOIDANCE SYSTEM' PROC. OF THE VEHICLE NAVIGATION AND INFORMATION SYSTEMS CONFERENCE, YOKOHAMA, AUG. 31 - SEPT. 2, 1994, pages 445-450, IEEE

V: Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Under the proviso of the objections raised under item VIII above, the subject matter of independent claims 1, 26 and 33 and, as a consequence, of the dependent claims 2-25, 27-32 and 34-37, is considered to meet the requirements of Article 33 (1-3) PCT.

1.1 Document D1 represents the closest piece of prior art on file with respect to all claims.

1.2 D1 discloses process for identifying a line in an input image (page 1, technical field; figures 1a-1e and 2; page 9), the line comprising a plurality of pixels corresponding to the line (eg, see abstract, lines 1-2; page 9, 1st par.; fi-gure 18), the process including an elementary operation comprising:

projecting pixels onto a projection axis defined by a rotation angle related to a reference axis, as to form a projection waveform (eg, figures 1a-1e);

analysing the projection waveform to identify characteristics indicative of a line (*ibid.*); and

if (and as long as) the analysis of histograms is not indicative of a line, rotating the projection axis by a predetermined angle (age 9, par. 2 - page 10, par. 2).

1.3 The fact that claim 1 specifies a histogram where D1 refers to "projection waveforms" is considered insignificant because both closely correspond to each other, as the skilled person is well aware. Moreover, it appears that the context of digital

image processing actually suggests the (approximative) representation of a "projection waveform" by a discrete sampling, ie, a "histogram".

1.4 D1 does not, however, teach or suggest to perform the line detection operation in parallel.

1.5 It is held that parallelization as such is well-known and so is the general desire to speed up a given process by parallelization. However, it is not considered to be obvious to perform N x S parallel operations as specified in claim 1, in order to detect S=2 lines simultaneously and each on one of N>3 predetermined projection axes.

1.6 By virtue of this feature, hence, the subject matter of present independent claim 1 is considered to evince an inventive step as required by Article 33 (3) PCT.

2 The same assessment applies to independent claim 26 under the proviso of the clarity problem under item VIII.10.2 and to claim 33 under the proviso of the clarity problems under items VIII.10.2 and 11.

3 To dependent claims 2-25, 27-32 and 34-37 applies the conditionally positive assessment of their respective independent claim by analogy.

VII: Certain defects in the international application

4 Documents D1 and D2 should have been acknowledged in the description and their relevant contents should be briefly discussed (Rule 5.1 (a) (ii) PCT).

5 The two-part form of claim 1 based on document D1 appears to be inappropriate with respect to the pixel characteristics (claim page 1, lines 14-17). Histogramming black pixels according to D1 (see, eg, figures 1a-1e) clearly and unambiguously corresponds to histogramming pixels of a certain "luminance, hue, and/or saturation" (claim page 1, line 15) for the special case of a black-and-white image (Rule 6.3 (b) (i) PCT).

6 Reference signs in parentheses should have been inserted in all claims according

to Rule 6.2 (b) PCT.

7 The phrase on page 16, lines 1-3, which states to "incorporate by reference" the contents of preceding PCT applications should have been deleted according to the PCT Examination Guidelines II-4.18.

8 The PCT application numbers cited on page 1, section 2, and page 16, 1st and 2nd par., should have been replaced by corresponding publication numbers.

9 On page 46, line 4, the wildcard "??" should have been replaced by "25".

VIII: Certain observations on the international application

10 The three independent claims 1, 26 and 33 do not correspond to each other to the highest possible degree (Article 6 PCT).

10.1 Specifically, both claims 26 and 33 fail to specify a means corresponding to the "image processing step used to select pixels" of claim 1 (claim page 1, lines 12-17). With respect to claim 26, the corresponding features are specified in claim 29, items i) and ii), with respect to claim 33 they are not specified at all.

10.2 Claims 26 and 33 fail to specify that there are N x S rotation units; requiring rotation units "for" S=2 sets and N>3 predetermined projection units does not imply their number. Moreover, claims 26 and 33 fail to clearly specify that said rotation units are to be operated in parallel (the phrase "through the rotation units" on claim page 8, line 18, is considered insufficient for this purpose).

As said claims stand, the rotation units might just represent redundant hardware to ensure fault tolerance - which is neither supported by the description nor solves the same technical problem as the subject matter of claim 1.

This omission is crucial since inventive step of present claim 1 is conceded by virtue of this very feature (cf item V.1.5 above).

11 Claim 33 is unclear for a number of reasons:

11.1 The meaning of the terms "class" and "domain" as apparently intended according

to claim 33 (cf, description, page 3, lines 1-3, and page 39, par. 2) are not clear from the claim, in contradition to the PCT Guidelines C-III, 4.2.

11.2 The function of the linear combination unit is not clear from claim 33 as well, nor is the function of the "validation signal" precisely clear (claim page 10, lines 6-9).

Specifically, it is not clear what said linear combination unit actually "combines" and how, and also according to which criteria the validation signal "selects one or more of the plurality of domains" and for what sort of "processing".

11.3 It is stressed that these issues should have been clear *from the wording of the claims alone* (Article 6 PCT and PCT Guidelines C-III, 4.2).

12 It is not clear from the claims precisely how said pixels are to be selected according to claims 1 and 29. Specifically, the meaning of DP, CO and velocity *a priori* has no established meaning with respect to a static input image whereas luminance, hue and saturation apparently have.

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PATENT COOPERATION TREATY

PCT

REC'D 04 DEC 2000

WIPO PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
300K PCT 362		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/EP99/00425	25/01/1999	25/08/1998
International Patent Classification (IPC) or national classification and IPC G06T7/00		
Applicant HOLDING B.E.V. SA et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 11 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
16/03/2000	29.11.2000
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Müller, M Telephone No. +49 89 2399 7409

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP99/00425

I. Basis of the report

1. This report has been drawn on the basis of *(substitute sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to the report since they do not contain amendments (Rules 70.16 and 70.17).)*:
Description, pages:

1-53	as originally filed				

Claims, No.:

1-37	as received on	24/08/2000	with letter of	22/08/2000	

Drawings, sheets:

1-16	as originally filed				

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   - ☐ the description, pages:
   - ☒ the claims, Nos.: 38-91

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-37
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-37 (if clarified)
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-37
	No:	Claims	

2. Citations and explanations
   see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Citations

Reference is made to the following documents:

D1: EP-A-0 380 659 (KABUSHIKI KAISHA KOMATSU SEISAKUSHO) 8 August 1990

D2: YAMADA K ET AL: 'IMAGE UNDERSTANDING BASED ON EDGE HISTOGRAM METHOD FOR REAR-END COLLISION AVOIDANCE SYSTEM' PROC. OF THE VEHICLE NAVIGATION AND INFORMATION SYSTEMS CONFERENCE, YOKOHAMA, AUG. 31 - SEPT. 2, 1994, pages 445-450, IEEE

V: Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Under the proviso of the objections raised under item VIII above, the subject matter of independent claims 1, 26 and 33 and, as a consequence, of the dependent claims 2-25, 27-32 and 34-37, is considered to meet the requirements of Article 33 (1-3) PCT.

1.1 Document D1 represents the closest piece of prior art on file with respect to all claims.

1.2 D1 discloses process for identifying a line in an input image (page 1, technical field; figures 1a-1e and 2; page 9), the line comprising a plurality of pixels corresponding to the line (eg, see abstract, lines 1-2; page 9, 1st par.; fi-gure 18), the process including an elementary operation comprising:

projecting pixels onto a projection axis defined by a rotation angle related to a reference axis, as to form a projection waveform (eg, figures 1a-1e);

analysing the projection waveform to identify characteristics indicative of a line (*ibid.*); and

if (and as long as) the analysis of histograms is not indicative of a line, rotating the projection axis by a predetermined angle (age 9, par. 2 - page 10, par. 2).

1.3 The fact that claim 1 specifies a histogram where D1 refers to "projection waveforms" is considered insignificant because both closely correspond to each other, as the skilled person is well aware. Moreover, it appears that the context of digital

image processing actually suggests the (approximative) representation of a "projection waveform" by a discrete sampling, ie, a "histogram".

1.4 D1 does not, however, teach or suggest to perform the line detection operation in parallel.

1.5 It is held that parallelization as such is well-known and so is the general desire to speed up a given process by parallelization. However, it is not considered to be obvious to perform N x S parallel operations as specified in claim 1, in order to detect S=2 lines simultaneously and each on one of N>3 predetermined projection axes.

1.6 By virtue of this feature, hence, the subject matter of present independent claim 1 is considered to evince an inventive step as required by Article 33 (3) PCT.

2 The same assessment applies to independent claim 26 under the proviso of the clarity problem under item VIII.10.2 and to claim 33 under the proviso of the clarity problems under items VIII.10.2 and 11.

3 To dependent claims 2-25, 27-32 and 34-37 applies the conditionally positive assessment of their respective independent claim by analogy.

VII: Certain defects in the international application

4 Documents D1 and D2 should have been acknowledged in the description and their relevant contents should be briefly discussed (Rule 5.1 (a) (ii) PCT).

5 The two-part form of claim 1 based on document D1 appears to be inappropriate with respect to the pixel characteristics (claim page 1, lines 14-17). Histogramming black pixels according to D1 (see, eg, figures 1a-1e) clearly and unambiguously corresponds to histogramming pixels of a certain "luminance, hue, and/or saturation" (claim page 1, line 15) for the special case of a black-and-white image (Rule 6.3 (b) (i) PCT).

6 Reference signs in parentheses should have been inserted in all claims according

to Rule 6.2 (b) PCT.

7 The phrase on page 16, lines 1-3, which states to "incorporate by reference" the contents of preceding PCT applications should have been deleted according to the PCT Examination Guidelines II-4.18.

8 The PCT application numbers cited on page 1, section 2, and page 16, 1st and 2nd par., should have been replaced by corresponding publication numbers.

9 On page 46, line 4, the wildcard "??" should have been replaced by "25".

VIII: Certain observations on the international application

10 The three independent claims 1, 26 and 33 do not correspond to each other to the highest possible degree (Article 6 PCT).

10.1 Specifically, both claims 26 and 33 fail to specify a means corresponding to the "image processing step used to select pixels" of claim 1 (claim page 1, lines 12-17). With respect to claim 26, the corresponding features are specified in claim 29, items i) and ii), with respect to claim 33 they are not specified at all.

10.2 Claims 26 and 33 fail to specify that there are N x S rotation units; requiring rotation units "for" S=2 sets and N>3 predetermined projection units does not imply their number. Moreover, claims 26 and 33 fail to clearly specify that said rotation units are to be operated in parallel (the phrase "through the rotation units" on claim page 8, line 18, is considered insufficient for this purpose).

As said claims stand, the rotation units might just represent redundant hardware to ensure fault tolerance - which is neither supported by the description nor solves the same technical problem as the subject matter of claim 1.

This omission is crucial since inventive step of present claim 1 is conceded by virtue of this very feature (cf item V.1.5 above).

11 Claim 33 is unclear for a number of reasons:

11.1 The meaning of the terms "class" and "domain" as apparently intended according

to claim 33 (cf, description, page 3, lines 1-3, and page 39, par. 2) are not clear from the claim, in contradition to the PCT Guidelines C-III, 4.2.

11.2 The function of the linear combination unit is not clear from claim 33 as well, nor is the function of the "validation signal" precisely clear (claim page 10, lines 6-9).

Specifically, it is not clear what said linear combination unit actually "combines" and how, and also according to which criteria the validation signal "selects one or more of the plurality of domains" and for what sort of "processing".

11.3 It is stressed that these issues should have been clear *from the wording of the claims alone* (Article 6 PCT and PCT Guidelines C-III, 4.2).

12 It is not clear from the claims precisely how said pixels are to be selected according to claims 1 and 29. Specifically, the meaning of DP, CO and velocity *a priori* has no established meaning with respect to a static input image whereas luminance, hue and saturation apparently have.

CLAIMS

1. A process for identifying a line in an input image, the image comprising a plurality of pixels corresponding to the line, the process including an elementary operation comprising:

- projecting pixels onto a projection axis defined by a rotation angle related to a reference axis, as to form a projection waveform;

- analyzing the projection waveform to identify characteristics indicative of a line;

characterised in that

- the projection waveform is an histogram;

- the image is processed in order to select pixels of the image having characteristics corresponding to characteristics of the line, the selected pixels being at least from the group consisting of luminance, hue, saturation, direction, DP, CO and velocity, DP identifying a significant variation of a pixel and CO being an updated calculated value of time constant;

- and that N x S elementary operations are done in parallel processing with the selected pixels on S =2 sets of N > 3 predetermined projection axis, each set being related to a set reference axis {x,y}, the N predetermined projection axis of each set being regularly distributed from the set reference axis with a stepping angle of 180°/N;

- and that, if the analysis of the histograms of a set are not indicative of a line:

the N predetermined projection axis of said set are rotated with a same rotation angle and the elementary operations are done until an analysis of the histograms is indicative of a line.

2. The process according to claim 1 characterised in that the elementary operations are done in parallel for the S=2 sets, the sets being chosen related to {x, y} orthogonal references axis.

3. The process according to the claim 2 characterised in that the references axis are chosen as being the horizontal and vertical axis of the image.

4. The process according to claim 1 characterised in that the elementary operations are done in parallel for the S=2 sets, the sets being chosen related to {x, y} non orthogonal references axis.

5. The process according to any one of claims 1 to 4 characterised in that the elementary operations are done in parallel for the S=2 sets of N=16 predefined projection axis.

6. The process according to one of claims 1 to 5 characterised in that it further comprises the identification of the orientation of the line, the process further comprising the step of:

if the analysis of the histograms of a set are not indicative of a line most closely perpendicular to one of N predetermined projection axis of said set:

the N predetermined projection axis of said set are rotated with a same rotation angle and the elementary operations are done until an analysis of the histograms is indicative of a line most closely perpendicular to one of N predetermined projection axis of said set.

7. The process according to claim 6 characterised in that the histogram characteristics comprise R =NBPTS/RMAX, and in that the line is determined to be most closely perpendicular to the predetermined projection axis at which R is a minimum, NBPTS being the number of points in the histogram and RMAX being the number of points at the maximum of the histogram.

8. The process according to one of the claim 1 to 7 characterised in that a camera is mounted on a vehicle and an input image of the road is acquired in order to identify a line on a road.

9. The process according to claim 8 characterised in that the line on a road is a broken line and that the step of analyzing the histogram to identify characteristics indicative of a line comprises time averaging the histogram over a succession of frames of the image.

10. The process according to claim 8 characterised in that the line on a road is a broken line and that the step of analyzing the histogram to identify characteristics indicative of a line

comprises analyzing the histogram over a succession of frames of the image to identify a periodic fluctuation in peaks of the histogram indicative of a broken line.

11. The process according to claim 8 characterised in that the line is a broken line and that the step of selecting pixels of the image having characteristics corresponding to characteristics of the line comprises selecting pixels in a first desired area of the image for selecting pixels associated with a first portion of the broken line, and selecting pixels in a second desired area of the image for selecting pixels associated with a second portion of the broken line adjacent to the first section; and

that the step forming histograms of the selected pixels projected onto a first set of N predetermined axis comprises forming first histograms of the selected first pixels projected onto a first set of N predetermined axis and forming second histograms of the selected second pixels projected onto the first set of N predetermined axis; and

that the step of analyzing the histogram to identify characteristics indicative of a line comprises analyzing the first and second histograms over a succession of frames of the image to identify a periodic movement of first pixels associated with the line from the first desired area to the second desired area.

12. The process according to claim 8 characterised in that the line is a broken line and that the step of selecting pixels of the image having characteristics corresponding to characteristics of the line comprises selecting pixels in a first desired area of the image for selecting pixels associated with a first portion of the broken line, and selecting pixels in a second desired area of the image for selecting pixels associated with a second portion of the broken line adjacent to the first section; and

that the step forming histograms of the selected pixels projected onto sets of N predetermined axis comprises forming first histograms of the selected first pixels projected onto a first set of N predetermined axis and forming second histograms of the selected

second pixels projected onto a second set of N predetermined axis; and

that the step of analyzing the histograms to identify characteristics indicative of a line comprises analyzing the histograms from first and second sets over a succession of frames of the image to identify a periodic movement of first pixels associated with the line from the first desired area to the second desired area.

13. The process according to any one of claims 8 to 12 characterised in that the line is a parallel double line and that the step of analyzing the histogram to identify characteristics indicative of a line comprises analyzing the histogram to identify two peaks characteristic of a parallel double line.

14. The process according to any one of claims 8 to 12 characterised in that a camera is mounted on a vehicle and an input image of the road is acquired in order to identify a line on a road which is a double line and that the step of selecting pixels of the image having characteristics corresponding to characteristics of the line comprises selecting pixels in a first desired area of the image at a first desired orientation in the image for selecting pixels associated with the first line, and selecting pixels in a second desired area of the image at a second desired orientation in the image for selecting pixels associated with the second line; and

that the step of forming histograms of the selected pixels projected onto sets of N predetermined axis comprises forming first histograms of the selected first pixels projected onto a first set of N predetermined axis and forming second histograms of the selected second pixels projected onto the first set of predetermined axis; and

that the step of analyzing the histograms to identify characteristics indicative of a line comprises analyzing each of the first and second histograms to identify characteristics indicative of a line; and

that if the analysis of the histograms of the first set are not indicative of a line:

the N predetermined projection axis of said set are rotated with a same rotation angle and the elementary operations are done until an analysis of the histograms is indicative of a line.

15. The process according to any one of claims 8 to 12 characterised in that a camera is mounted on a vehicle and an input image of the road is acquired in order to identify a line on a road which is a double line and that the step of selecting pixels of the image having characteristics corresponding to characteristics of the line comprises selecting pixels in a first desired area of the image at a first desired orientation in the image for selecting pixels associated with the first line, and selecting pixels in a second desired area of the image at a second desired orientation in the image for selecting pixels associated with the second line; and

that the step of forming histograms of the selected pixels projected onto sets of N predetermined axis comprises forming first histograms of the selected first pixels projected onto a first set of N predetermined axis and forming second histograms of the selected second pixels projected onto a second set of predetermined axis; and

that the step of analyzing the histograms to identify characteristics indicative of a line comprises analyzing histograms of first and second sets to identify characteristics indicative of a line; and

that if the analysis of the histograms of a set are not indicative of a line:

the N predetermined projection axis of said set are rotated with a same rotation angle and the elementary operations are done until an analysis of the histograms is indicative of a line.

16. The process according to any one of claims 8 to 15 characterised in that a camera is mounted on a vehicle and an input image of the road is acquired in order to detect a lane on a road from the vehicle-mounted camera, the lane being defined by a first line on one side thereof and a second line on the other side thereof, the process comprising the steps of:

acquiring an image of the road from the camera, each of the first and second side lines comprising a plurality of pixels in the image;

selecting pixels of the image in a first desired area of the image at a first desired orientation in the image for selecting pixels associated with the first side line, and selecting pixels in a second desired area of the image at a second desired orientation in the image for selecting pixels associated with the second side line;

identifying the first side line and the second side line.

17. The process according to claim 16 characterised in that a camera is mounted on a vehicle and an input image of the road is acquired in order to detect a vehicle in an adjacent lane from a camera mounted to a subject vehicle, the adjacent lane being defined by a first line on one side thereof and a second line on the other side thereof, the process comprising the steps of:

acquiring an image of the road from the camera, each of the first and second side lines comprising a plurality of pixels in the image;

detecting an adjacent lane by identifying the first side line and the second side line of said adjacent lane;

selecting pixels of the image having characteristics corresponding to characteristics of a vehicle;

the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting such pixels in an area bounded by the first and second side lines;

forming a histogram of the selected pixels projected onto a first set of predetermined axis; and

analyzing the histogram to detect characteristics indicative of a vehicle.

18. The process according to claim 17 characterised in that the step of analyzing the histogram to detect characteristics indicative of a vehicle comprises detecting a histogram having NBPTS exceeding a threshold, NBPTS being the number of points in the histogram.

19. The process according to claim 17 or 18 characterised in that the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels having a color or luminance characteristic of taillights.

20. The process according to claim 19 analyzing the histogram to detect characteristics indicative of a vehicle comprises analyzing the histogram to separately detect each taillight.

21. The process according to claim 17 or 18 characterised in that the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels having a color or luminance characteristic of headlights.

22. The process according to claim 21 analyzing the histogram to detect characteristics indicative of a vehicle comprises analyzing the histogram to separately detect each headlight.

23. The process according to one of claims 17 to 22 characterised in that the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels moving in a direction parallel to a direction of the lane.

24. The process according to one of claims 17 to 23 characterised in that the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels moving in a direction generally parallel to one of the first or second side lines.

25. The process according to one of claims 17 to 22 characterised in that it comprises the step of dynamically adapting in function of results at least one or more of the following parameters: classification, areas, histograms.

26. An apparatus for identifying the orientation of a line in an input image, the line comprising a plurality of pixels, said apparatus having means for:

- projecting pixels onto a projection axis defined by a rotation angle related to a reference axis, as to form a projection waveform;

- analyzing the projection waveform to identify characteristics indicative of a line;

characterised in that the projection waveform is an histogram and that it comprises means for executing the process of any one of previous claims, said means being at least an image processing system interfaced with a controller:

- the image processing system comprising histogram formation units and rotation units for S = 2 sets of N >3 predetermined projection axis, said histogram formation units forming histograms of the pixels projected on the predetermined projection axis of sets, and said rotation units rotating by a same rotation angle the predetermined projection axis of sets;

- the controller analyzing the histograms to determine when the histograms of a set comprises characteristics indicating that the line is most closely perpendicular to one of the predetermined axis of said set, and

- the controller being able to rotate the N predetermined axis of a set through the rotation units.

27. The apparatus according to claim 26 characterised in that the rotation unit comprises a Hough transform unit performing a Hough transform on the pixels for enabling rotation of the predetermined axis.

28. The apparatus according to claim 26 or 27 characterised in that each histogram formation unit comprises an area selection memory for selecting an area of an image for which to form a histogram, the controller controlling the histogram formation unit to select pixels in a desired area of the image for detecting the line.

29. The apparatus according to any one of claims 26 to 28 characterised in that the interface between the image processing system and the controller comprises:

input signals from the controller to the image processing system including control signals selected from the group consisting of:

i) signals for selecting domains for processing by the image processing system, said domains being selected from the group consisting of luminance, hue, saturation, CO, DP, direction, and velocity;

ii) signals for selecting classes of pixels within each domain for processing by the image processing system,

iii) signals for selecting rotation angle of sets for formation of histograms projected on the predefined axes of the sets, and

iv) signals for selecting an area of an image for processing by the image processing system; and

output signals from the image processing system to the controller including signals resultant from processing the input signals selected from the group consisting of:

i) signals containing information on histograms formed in the image processing system, and

ii) signals containing histograms formed in the image processing system.

30. The apparatus according to claim 29 characterised in that the signals containing information on histograms formed in the image processing system are selected from the group consisting of MIN, MAX, NBPTS, RMAX, POSRMAX, MIN being the minimum of an histogram, MAX being the maximum of an histogram, POSRMAX being the position of the maximum of an histogram.

31. The apparatus according to any one of claims 26 to 30, characterised in that the apparatus is built in a single chip (MOS).

32. The apparatus according to any one of claims 26 to 31, characterised in that it further comprises a physical link which is a standard automotive bus.

33. A device for identifying an object in an input signal, the object comprising pixels in one of a plurality of classes in one of a plurality of domains, the input signal comprising a succession of

frames, each frame comprising a succession of pixels, the apparatus comprising:

a classifier (25b) for each domain, the classifier classifying pixels within each domain in selected classes within the domain;

a linear combination unit for each domain, the linear combination unit generating a validation signal for the domain, the validation signal selecting one or more of the plurality of domains for processing;

rotation units for rotating S=2 sets of N >3 predetermined projection axis;

histogram formation units for forming histograms for pixels of the output signal within the classes selected by the classifier within each domain selected by the validation signal projected onto sets of predetermined projection axis; and

a controller for controlling the classifier, linear combination unit, rotation unit, and histogram formation unit for identifying the object.

34. The device according to claim 33 wherein the rotation unit performs a Hough transform.

35. The device according to claim 33 or 34 wherein the rotation units enable the rotation of a first set of predetermined axis and of a second set of predetermined axis, and wherein the histogram formation units are capable of forming first histograms projected onto the first set of predetermined axis, and of forming second histograms projected onto the second set of predetermined axis.

36. The device according to any one of claims 33 to 35 characterised in that the object is in an area of the image, and the device further comprises an area selection unit for selecting an area of the image, the histogram formation units forming histograms for pixels of the input signal within the selected area of the image, and the controller further controls the area selection unit for enabling selection of objects in a desired area of an image.

37. The device according to any one of claims 33 to 36 characterised in that the object is in an area of the image, and the device further comprises a masking unit for masking an area of the image to prevent consideration of the pixels in the masked area, and the controller further controls the masking unit for identifying the object.

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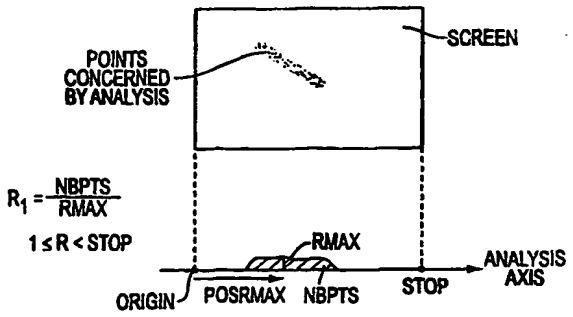
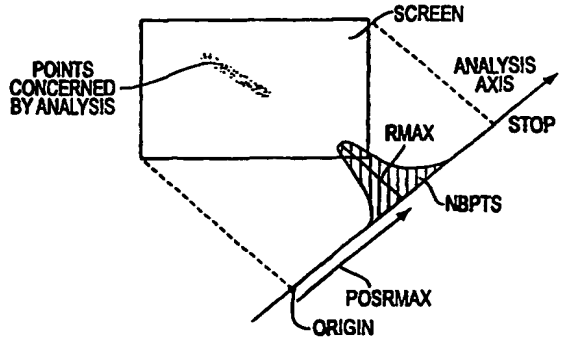
(54) Title: IMAGE PROCESSING APPARATUS AND METHOD

(57) Abstract

In a process for identifying the orientation of a line in an image, a histogram is formed of pixels of the line projected onto an axis. The axis is rotated and a histogram is formed of the pixels projected onto the rotated axis until the histogram includes charateristics indicating that the line is most closely perpendicular to the rotated axis. In a process of detecting a line on a road, an image is acquired of the road, and pixels of the image having characteristics corresponding to characteristics of the line are selected. A histogram is formed of the selected pixels projected onto an axis. The axis is rotated and a histogram formed of the selected pixels projected onto the rotated axis until the histogram includes characteristics indicative of a line. In a process of detecting a lane on a road having left and righ side lines, pixels of the image in a first area of the image at a first orientation and pixels in a second area of the image at a second orientation in the image are selected for selecting pixels associated with the lines. Histograms are formed projected on the first and second axes, respectively, and the axes are rotated until each histogram includes characteristics of a line. Also disclosed is a process of detecting a vehicle in an adjacent lane, systems for performing the aforementioned processes, systems for identifying an object and an input signal, and an interface between an image processing system and a controller.





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INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 380 659 A (KABUSHIKI KAISHA KOMATSU SEISAKUSHO) 8 August 1990	79
Y	see claims 1,3,4	1,33
Y	EP 0 394 959 A (FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.) 31 October 1990 see abstract	1,4,21, 33,37,53

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Chateau, J-P

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	YAMADA K ET AL: "IMAGE UNDERSTANDING BASED ON EDGE HISTOGRAM METHOD FOR REAR-END COLLISION AVOIDANCE SYSTEM" PROCEEDINGS OF THE VEHICLE NAVIGATION AND INFORMATION SYSTEMS CONFERENCE, YOKOHAMA, AUG. 31 - SEPT. 2, 1994,31 August 1994, pages 445-450, XP000641348 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS see page 446, right-hand column, paragraph 3; figure 3	24,56,83
Y		4,21,37, 53
A		65,69, 71,72

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. Application No
PCT/EP 99/00425

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		US 5181258 A	19-01-1993
EP 394959 A	31-10-1990	DE 3913620 A	31-10-1990
		DE 59010833 D	13-08-1998

CLAIMS

1. A process for identifying the orientation of a line in an input image, the line comprising a plurality of pixels, the process comprising the steps of:

forming a histogram of the pixels projected onto a first axis;

rotating the first axis and forming a histogram of the pixels projected onto the rotated first axis until the histogram comprises characteristics indicating that the line is most closely perpendicular to the rotated first axis.

2. The process according to claim 1 wherein the histogram characteristics comprise R =NBPTS/RMAX, and wherein the line is determined to be most closely perpendicular to the rotated first axis at which R is a minimum.

3. The process according to claim 1 wherein the first axis is the horizontal or vertical axis of the image.

4. A process of detecting a line on a road from a vehicle-mounted camera, the process comprising the steps of:

acquiring an image of the road, the image comprising a plurality of pixels corresponding to the line;

selecting pixels of the image having characteristics corresponding to characteristics of the line;

forming a histogram of the selected pixels projected onto a first axis;

analyzing the histogram to identify characteristics indicative of a line;

rotating the first axis and forming a histogram of the selected pixels projected onto the rotated first axis until the histogram comprises characteristics indicative of a line.

5. The process according to claim 4 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a line comprises selecting pixels selected from the group consisting of luminance, hue, saturation, direction, DP, CO and velocity.

6. The process according to claim 4 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a line comprises selecting pixels in a desired area of the image.

7. The process according to claim 4 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a line comprises selecting pixels in a desired area of the image at a desired orientation in the image.

8. The process according to claim 4 further comprising repeating the step of rotating the first axis and forming a histogram of the selected pixels until the histogram comprises characteristics indicating that the line is most closely perpendicular to the rotated first axis.

9. The process according to claim 8 wherein the histogram characteristics comprise R =NBPTS/RMAX, and wherein the line is determined to be most closely perpendicular to the rotated first axis at the rotated first axis at which R is a minimum.

10. The process according to claim 8 wherein the first axis is the horizontal or vertical axis of the image.

11. The process according to claim 4 wherein the line is a double line and wherein:

the step of selecting pixels of the image having characteristics corresponding to characteristics of the line comprises selecting first pixels in a first desired area of the image at a first desired orientation in the image for selecting pixels associated with the first line, and selecting pixels in a second desired area of the image at a second desired orientation in the image for selecting pixels associated with the second line;

the step of forming a histogram of the selected pixels projected onto a first axis comprises forming a first histogram of the selected first pixels projected onto a first axis and forming a second histogram of the selected second pixels projected onto the first axis;

the step of analyzing the histogram to identify characteristics indicative of a line comprises analyzing each of the first and second histograms to identify characteristics indicative of a line; and

the step of rotating the first axis comprises rotating the first axis and forming first and second histograms of the selected first and second pixels respectively projected onto the rotated first axis until each of the first and second histograms comprises characteristics indicative of a line.

12. The process according to claim 11 further comprising repeating the step of rotating the first axis and forming first and second histogram until each of the first and second histograms comprises characteristics indicative of a line and until at least one of the first and second histograms comprises characteristics indicating that the line associated with such histogram is most closely perpendicular to the rotated first axis.

13. The process according to claim 12 wherein the histogram characteristics comprise R =NBPTS/RMAX, and wherein the line is determined to be most closely perpendicular to the rotated first axis at the rotated first axis at which R is a minimum.

14. The process according to claim 11 wherein the double lines are parallel to the other and each line is selected from the group consisting of solid and broken lines.

15. The process according to claim 4 wherein the line is a parallel double line and wherein the step of analyzing the histogram to identify characteristics indicative of a line comprises analyzing the histogram to identify two peaks characteristic of a parallel double line.

16. The process according to claim 4 wherein the line is solid or broken.

17. The process according to claim 4 wherein the line is a broken line and wherein:

the step of analyzing the histogram to identify characteristics indicative of a line comprises time averaging the histogram over a succession of frames of the image.

18. The process according to claim 4 wherein the line is a broken line and wherein:

the step of analyzing the histogram to identify characteristics indicative of a line comprises analyzing the histogram over a succession of frames of the image to identify a periodic fluctuation in peaks of the histogram indicative of a broken line.

19. The process according to claim 4 wherein the line is a broken line and wherein:

the step of selecting pixels of the image having characteristics corresponding to characteristics of the line comprises selecting first pixels in a first desired area of the image for selecting pixels associated with a first portion of the broken line, and selecting pixels in a second desired area of the image for selecting pixels associated with a second portion of the broken line adjacent to the first section;

the step forming a histogram of the selected pixels projected onto a first axis comprises forming a first histogram of the selected first pixels projected onto a first axis and forming a second histogram of the selected second pixels projected onto the first axis; and

the step of analyzing the histogram to identify characteristics indicative of a line comprises analyzing the first and second histograms over a succession of frames of the image to identify a periodic movement of first pixels associated with the line from the first desired area to the second desired area.

20. The process according to claim 11 further comprising repeating the step of rotating the first axis and forming first and second histograms until each of the first and second histograms comprises characteristics indicative of a line and until at least one of the first and second histograms comprises characteristics indicating that the line associated with such histogram is most closely perpendicular to the rotated first axis.

21. A process of detecting a lane on a road from a vehicle-mounted camera, the lane being defined by a first line on one side thereof and a second line on the other side thereof, the process comprising the steps of:

acquiring an image of the road from the camera, each of the first and second lines comprising a plurality of pixels in the image;

selecting pixels of the image in a first desired area of the image at a first desired orientation in the image for selecting pixels associated with the first line, and

selecting pixels in a second desired area of the image at a second desired orientation in the image for selecting pixels associated with the second line;

forming a first histogram of the selected first pixels projected onto a first axis and forming a second histogram of the selected second pixels projected onto a second axis;

analyzing each of the first and second histograms to identify characteristics in each histogram indicative of a line; and

until the first histogram comprises characteristics indicative of a line, rotating the first axis and forming a first histogram of the first pixels projected onto the rotated first axis, and until the second histogram comprises characteristics indicative of a line, rotating the second axis and forming a second histogram of the second pixels projected onto the rotated second axis.

22. The process according to claim 21 further comprising repeating the step of rotating the first axis and forming a first histogram and rotating the second axis and forming a second histogram until each of the first and second histograms comprises characteristics indicative of a line and until at least one of the first and second histograms comprises characteristics indicating that the line associated with such histogram is most closely perpendicular to the rotated first axis.

23. The process according to claim 22 wherein the histogram characteristics comprise R =NBPTS/RMAX, and wherein the line is determined to be most closely perpendicular to the rotated first axis at the rotated first or second axis at which R is a minimum.

24. A process for detecting a vehicle in an adjacent lane from a camera mounted to a subject vehicle, the process comprising the steps of:

acquiring an image of the adjacent lane;

selecting pixels of the image having characteristics corresponding to characteristics of a vehicle;

forming a histogram of the selected pixels projected onto a first axis; and

analyzing the histogram to detect characteristics indicative of a vehicle.

25. The process according to claim 24 wherein the adjacent lane is defined by first and second side lines each of the first and second side lines comprising a plurality of pixels in the image, wherein:

the step of acquiring an image of the adjacent lane comprises:

i) selecting pixels of the image in a first desired area of the image at a first desired orientation in the image for selecting pixels associated with the first line, and selecting pixels in a second desired area of the image at a second desired orientation in the image for selecting pixels associated with the second line;

ii) forming a first histogram of the selected first pixels projected onto a first axis and forming a second histogram of the selected second pixels projected onto a second axis;

iii) analyzing each of the first and second histograms to identify characteristics in each histogram indicative of a line; and

iv) until the first histogram comprises characteristics indicative of a line, rotating the first axis and forming a first histogram of the first pixels projected onto the rotated first axis, and until the second histogram comprises characteristics indicative of a line, rotating the second axis and forming a second histogram of the second pixels projected onto the rotated second axis; and

the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting such pixels in an area bounded by the first and second side lines.

26. The process according to claim 24 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels selected from the group consisting of luminance, hue, saturation, DP, velocity and direction.

27. The process according to claim 24 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels having a color or luminance characteristic of taillights.

28. The process according to claim 27 analyzing the histogram to detect characteristics indicative of a vehicle comprises analyzing the histogram to separately detect each taillight.

29. The process according to claim 24 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels having color or luminance characteristics of headlights.

30. The process according to claim 24 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels moving in a direction parallel to a direction of the lane.

31. The process according to claim 25 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a vehicle comprises selecting pixels moving in a direction generally parallel to one of the first or second side lines.

32. The process according to claim 24 wherein the step of analyzing the histogram to detect characteristics indicative of a vehicle comprises detecting a histogram having NBPTS exceeding a threshold.

33. An apparatus for identifying the orientation of a line in an input image, the line comprising a plurality of pixels, the apparatus comprising:

a histogram formation unit for forming a histogram of the pixels projected onto a first axis; and

a controller for selectively rotating the first axis, the histogram formation unit forming a histogram of the pixels projected onto the rotated first axis, the controller analyzing the histogram to determine when the histogram comprises characteristics indicating that the line is most closely perpendicular to the rotated first axis.

34. The apparatus according to claim 33 wherein the histogram formation unit comprise a Hough transform unit performing a Hough transform on the pixels for enabling rotation of the first axis.

35. The apparatus according to claim 33 wherein the histogram formation unit computes R =NBPTS/RMAX, and wherein the controller determines the

rotated first axis at which R is a minimum to identify the line most closely perpendicular to the rotated first axis.

36. The apparatus according to claim 33 wherein the first axis is the horizontal or vertical axis of the image.

37. An apparatus for detecting a line on a road, which comprises:

a vehicle-mounted camera acquiring an image of the road, the line comprising a plurality of pixels in the image;

a controller; and

a histogram formation unit for forming a histogram on pixels having selected characteristics on a selected axis,

the controller controlling the histogram formation unit to select pixels of the image having characteristics corresponding to characteristics of a line and to form a histogram projected onto a first axis, the controller analyzing the histogram to identify characteristics indicative of a line, the controller further rotating the first axis and controlling the histogram formation unit to form a histogram projected onto the rotated first axis and analyzing the histogram until the histogram comprises characteristics indicative of a line.

38. The apparatus according to claim 37 wherein the selected characteristics are selected from the group consisting of luminance, hue, saturation, direction, DP, CO and velocity.

39. The apparatus according to claim 37 wherein the histogram formation unit comprises an area selection memory for selecting an area of an image for which to form a histogram, the controller controlling the histogram formation unit to select pixels in a desired area of the image for detecting the line.

40. The apparatus according to claim 37 wherein the histogram formation unit comprises an area selection memory for selecting an area of an image for which to form a histogram and an angle selection memory for selecting an orientation angle for forming a histogram, the controller controlling the histogram formation unit to select pixels in a desired area of the image and to form a histogram at a desired orientation angle for detecting the line.

41. The apparatus according to claim 40 wherein the histogram formation unit comprise a Hough transform unit performing a Hough transform on the pixels for enabling rotation of the first axis for selecting pixels at the desired orientation angle.

42. The apparatus according to claim 37 wherein the controller rotates the first axis and the histogram formation unit forms a histogram of the selected pixels until the controller determines that the histogram comprises characteristics indicating that the line is most closely perpendicular to the rotated first axis.

43. The apparatus according to claim 42 wherein the histogram formation unit computes R =NBPTS/RMAX, and wherein the controller determines the rotated first axis at which R is a minimum to identify the line most closely perpendicular to the rotated first axis.

44. The apparatus according to claim 37 wherein the line is a double line and wherein the histogram formation unit comprises an area selection memory for selecting an area of an image for which to form a histogram and an angle selection memory for selecting an orientation angle for forming a histogram,

the controller controlling the histogram formation unit for selecting pixels of the image having characteristics corresponding to characteristics of a line in a first desired area of the image at a first desired orientation in the image for selecting pixels associated with a first line of the double line and controlling the histogram formation unit for selecting pixels in a second desired area of the image at a second desired orientation in the image for selecting pixels associated with the second line,

the histogram formation unit forming a first histogram of the selected first pixels projected onto the first axis and forming a second histogram of the selected second pixels projected onto the first axis, the controller analyzing each of the first and second histograms to identify characteristics indicative of a line and rotating the first axis until each of the first and second histograms comprises characteristics indicative of a line.

45. The apparatus according to claim 44 wherein the controller rotates the first axis until each of the first and second histograms comprises characteristics indicative of a line and until at least one of the first and second histograms

comprises characteristics indicating that the line associated with such histogram is most closely perpendicular to the rotated first axis.

46. The apparatus according to claim 44 wherein the double lines are parallel to the other and each line is selected from the group consisting of solid and broken lines.

47. The apparatus according to claim 37 wherein the line is a parallel double line and wherein the controller analyzes the histogram to identify two peaks characteristic of a parallel double line.

48. The apparatus according to claim 37 wherein the line is solid or broken.

49. The apparatus according to claim 37 wherein the line is a broken line and wherein the controller time averages the histogram over a succession of frames of the image to identify characteristics indicative of a broken line.

50. The apparatus according to claim 37 wherein the line is a broken line and wherein the controller time analyzes the histogram over a succession of frames of the image to identify a periodic fluctuation in peaks of the histogram indicative of a broken line.

51. The apparatus according to claim 37 wherein the line is a broken line and wherein the controller controls the histogram formation unit to form a first histogram of first pixels in a first desired area of the image associated with a first portion of the broken line, and to form a second histogram of second pixels in a second desired area of the image associated with a second portion of the broken line adjacent to the first section, each of the first and second histograms being projected onto the first axis, the controller analyzing the first and second histograms over a succession of frames of the image to identify a periodic movement of first pixels associated with the line from the first desired area to the second desired area.

52. The apparatus according to claim 44 wherein the controller rotates the first axis for forming first and second histogram until each of the first and second histograms comprises characteristics indicative of a line and until at least one of

section, each of the first and second histograms being projected onto the first axis, the controller analyzing the first and second histograms over a succession of frames of the image to identify a periodic movement of first pixels associated with the line from the first desired area to the second desired area.

52. The apparatus according to claim 44 wherein the controller rotates the first axis for forming first and second histogram until each of the first and second histograms comprises characteristics indicative of a line and until at least one of the first and second histograms comprises characteristics indicating that the line associated with such histogram is most closely perpendicular to the rotated first axis.

53. An apparatus for detecting a lane on a road, the lane being defined by a first line on one side thereof and a second line on the other side thereof, the apparatus comprising:

a vehicle-mounted camera for acquiring an image of the road, each of the first and second lines comprising a plurality of pixels in the image;

a controller; and

a histogram formation unit for selecting pixels in an image having particular characteristics and for forming a histogram of the selected pixels,

the controller controlling the histogram formation unit for selecting pixels of the image in a first desired area of the image and for forming a histogram of the selected pixels in the first desired area projected onto a first axis for forming a first histogram of pixels associated with the first line, and further controlling the histogram formation unit for selecting pixels in a second desired area of the image and for forming a second histogram of the selected pixels in the second desired area projected onto a second axis for forming a histogram of pixels associated with the second line,

the controller analyzing each of the first and second histograms to identify characteristics in each histogram indicative of a line, and

the controller rotating the first axis until the first histogram comprises characteristics indicative of a line, and rotating the second axis until the second histogram comprises characteristics indicative of a line.

54. The apparatus according to claim 53 wherein the controller rotates the first axis and the second axis until each of the first and second histograms comprises characteristics indicative of a line and until at least one of the first and second histograms comprises characteristics indicating that the line associated with such histogram is most closely perpendicular to the rotated first axis.

55. The apparatus according to claim 53 wherein the histogram formation unit computes R =NBPTS/RMAX for each of the first and second histograms, and wherein the controller determines the rotated first axis at which R is a minimum to determine when the first line is most closely perpendicular to the rotated first axis, and wherein the controller determines the rotated second axis at which R is a minimum to determine when the second line is most closely perpendicular to the rotated second axis.

56. An apparatus for detecting a vehicle in an adjacent lane from a subject vehicle, the apparatus comprising:

a camera mounted to the subject vehicle for acquiring an image of the adjacent lane;

a histogram formation unit for selecting pixels of the image and for forming a histogram of such images; and

a controller for controlling the histogram formation unit to select pixels having characteristics corresponding to characteristics of a vehicle and for analyzing the histogram of such pixels to detect characteristics indicative of a vehicle.

57. The apparatus according to claim 56 wherein the adjacent lane is defined by first and second side lines, each of the first and second side lines comprising a plurality of pixels in the image, and wherein:

the controller controls the histogram formation unit for i) selecting pixels of the image in a first desired area of the image at a first desired orientation in the image for selecting pixels associated with the first side line, and selecting pixels in a second desired area of the image at a second desired orientation in the image for selecting pixels associated with the second side line, and ii) forming a first histogram of the selected first pixels projected onto a first axis and forming a second histogram of the selected second pixels projected onto a second axis;

the controller analyzes each of the first and second histograms to identify characteristics in each histogram indicative of a line;

until the first histogram comprises characteristics indicative of a line, the controller rotates the first axis and controls the histogram formation unit to form a first histogram of the first pixels projected onto the rotated first axis, and until the second histogram comprises characteristics indicative of a line, the controller rotates the second axis and causes the histogram formation unit to form a second histogram of the second pixels projected onto the rotated second axis; and

the controller controlling the histogram formation unit to select pixels of the image having characteristics corresponding to characteristics of a vehicle comprises in an area bounded by the first and second side lines.

58. The apparatus according to claim 56 wherein the pixel characteristics corresponding to characteristics of a vehicle are selected from the group consisting of luminance, hue, saturation, DP, velocity and direction.

59. The apparatus according to claim 56 wherein the controller controls the histogram formation unit to select pixels having a color or luminance characteristic of taillights.

60. The apparatus according to claim 59 wherein the controller analyzes the histogram to separately detect each taillight.

61. The apparatus according to claim 56 wherein the controller controls the histogram formation unit to select pixels having color or luminance characteristics of headlights.

62. The apparatus according to claim 56 wherein the controller controls the histogram formation unit to select pixels moving in a direction parallel to a direction of the lane.

63. The process according to claim 57 wherein the controller controls the histogram formation unit to select pixels moving in a direction generally parallel to one of the first or second side lines.

64. The process according to claim 56 wherein the controller detects a histogram having NBPTS exceeding a threshold in order to identify a vehicle.

65. An apparatus for identifying an object in an input signal, the object comprising pixels in one of a plurality of classes in one of a plurality of domains, the input signal comprising a succession of frames, each frame comprising a succession of pixels, the apparatus comprising:

a classifier for each domain, the classifier classifying pixels within each domain in selected classes within the domain;

a linear combination unit for each domain, the linear combination unit generating a validation signal for the domain, the validation signal selecting one or more of the plurality of domains for processing;

a rotation unit for enabling selection of a histogram formation axis;

a histogram formation unit for forming a histogram for pixels of the output signal within the classes selected by the classifier within each domain selected by the validation signal projected onto the histogram formation axis; and

a controller for controlling the classifier, linear combination unit, rotation unit, and histogram formation unit for identifying the object.

66. The apparatus according to claim 65 wherein the rotation unit performs a Hough transform.

67. The apparatus according to claim 65 wherein the rotation unit enables selection of a first histogram formation axis and a second histogram formation axis, and wherein the histogram formation unit is capable of forming a first histogram projected onto the first histogram formation axis, and of forming a second histogram projected onto the second histogram formation axis.

68. The apparatus according to claim 65 wherein the object is in an area of the image, and further comprising an area selection unit for selecting an area of the image, the histogram formation unit forming a histogram for pixels of the output signal within the selected area of the image, and the controller controlling the area selection unit for enabling selection of objects in a desired area of an image.

69. An apparatus for identifying an object in an input signal, the object comprising pixels in an area of the image in one of a plurality of classes in one of a

plurality of domains, the input signal comprising a succession of frames, each frame comprising a succession of pixels, the apparatus comprising:

a classifier for each domain, the classifier classifying pixels within each domain in selected classes within the domain;

a linear combination unit for each domain, the linear combination unit generating a validation signal for the domain, the validation signal selecting one or more of the plurality of domains for processing;

an area selection unit for selecting an area of the image;

a histogram formation unit for forming a histogram for pixels of the output signal within the selected area of the image within the classes selected by the classifier within each domain selected by the validation signal projected onto the histogram formation axis; and

a controller for controlling the classifier, linear combination unit, area selection unit, and histogram formation unit for identifying the object.

70. The apparatus according to claim 69 further comprising a rotation unit for enabling selection of a histogram formation axis, the histogram formation unit forming a histogram for pixels of the output signal projected onto the histogram formation axis.

71. An apparatus for identifying an object in an input signal, the object comprising pixels in an area of the image in one of a plurality of classes in one of a plurality of domains, the input signal comprising a succession of frames, each frame comprising a succession of pixels, the apparatus comprising:

a classifier for each domain, the classifier classifying pixels within each domain in selected classes within the domain;

a linear combination unit for each domain, the linear combination unit generating a validation signal for the domain, the validation signal selecting one or more of the plurality of domains for processing;

a masking unit for masking an area of the image to prevent consideration of the pixels in the masked area;

a histogram formation unit for forming a histogram for pixels of the output signal outside the masked area but within the classes selected by the classifier and within each domain selected by the validation signal projected onto the histogram formation axis; and

a controller for controlling the classifier, linear combination unit, masking unit, and histogram formation unit for identifying the object.

72. An interface between an image processing system and a controller, the interface comprising:

input signals from the controller to the image processing system including control signals selected from the group consisting of:

i) signals for selecting domains for processing by the image processing system,

ii) signals for selecting classes of pixels within each domain for processing by the image processing system,

iii) signals for selecting axes for formation of histograms projected on the selected axes, and

iv) signals for selecting an area of an image for processing by the image processing system; and

output signals from the image processing system to the controller including signals resultant from processing the input signals selected from the group consisting of:

i) signals containing information on histograms formed in the image processing system, and

ii) signals containing histograms formed in the image processing system.

73. The interface according to claim 72 wherein the domains are selected from the group consisting of luminance, hue, saturation, CO, DP, direction, and velocity.

74. The interface according to claim 72 wherein the signals containing information on histograms formed in the image processing system are selected from the group consisting of MIN, MAX, NBPTS, RMAX, POSRMAX.

75. An apparatus according to claim 53, wherein the apparatus is built in a single chip (MOS).

76. An interface according to claim 72, wherein the physical link is a standard automotive bus.

77. A process according to claim 1, wherein it is possible to dynamically adapt in function of results at least one or more of the following parameters: classification, areas, histograms.

78. Use of an interface according to claim 72 with a physical link according to claim 76 and according to claim 77.

79. A process for identifying the orientation of a line in an input image, the line comprising a plurality of pixels, the process comprising the steps of:

forming histograms of the pixels projected onto multiple axes;

process until the histrograms comprise characteristics indicating that the line is most closely perpendicular to one of the multiple axes.

80. The process according to claim 79, wherein the histograms characteristics comprise R = NBPTS/RMAX, and wherein the line is determined to be most closely perpendicular to one of the multiple axes at which R is a minimum.

81. The process according to claim 79, wherein one of the multiple axes is the horizontal or vertical axis of the image.

82. The process according to claim 79, wherein processing is done using parallel computation.

83. A process of detecting a line on a road from a vehicle-mounted camera, the process comprising the steps of:

acquiring an image of the road, the image comprising a plurality of pixels corresponding to the line;

selecting pixels of the image having characteristics corresponding to characteristics of the line;

forming histograms of the selected pixels projected onto multiple axes;

analysing the histograms to identify characteristics indicative of a line;

process until one of the histograms comprises characteristics indicative of a line.

84. The process according to claim 83 wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a line comprises selecting pixels selected from the group consisting of luminance, hue, saturation, direction, DP, CO and velocity.

85. The process according to claim 83, wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a line comprises selecting pixels in a desired area of the image.

86. The process according to claim 83, wherein the step of selecting pixels of the image having characteristics corresponding to characteristics of a line comprises selecting pixels in a desired area of the image at a desired orientation in the image.

87. The process according to claim 83, further comprising repeating the step of rotating the multiple axes and forming histograms of the selected pixels until one of the histograms comprises characteristics indicting that the line is most closely perpendicular to one of the multiple axes.

88. The process according to claim 87, wherein the histogram characteristics comprise R = NPBTS/RMAX, and wherein the line is determined to be most closely perpendicular to one of the multiple axes at one of the multiple axes at which R is a minimum.

89. The process according to claim 87, wherein one of the multiple axes is the horizontal or vertical axes of the image.

90. Process according to claim 87, wherein processing is done using parallel computation.

91. A process according to claim 79, comprising the step of dynamically adapting in function of the results at least one of the following parameters: classification, areas, histograms.

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(57) Abstract

In a process for identifying the orientation of a line in an image, a histogram is formed of pixels of the line projected onto an axis. The axis is rotated and a histogram is formed of the pixels projected onto the rotated axis until the histogram includes charateristics indicating that the line is most closely perpendicular to the rotated axis. In a process of detecting a line on a road, an image is acquired of the road, and pixels of the image having characteristics corresponding to characteristics of the line are selected. A histogram is formed of the selected pixels projected onto an axis. The axis is rotated and a histogram formed of the selected pixels projected onto the rotated axis until the histogram includes characteristics indicative of a line. In a process of detecting a lane on a road having left and righ side lines, pixels of the image in a first area of the image at a first orientation and pixels in a second area of the image at a second orientation in the image are selected for selecting pixels associated with the lines. Histograms are formed projected on the first and second axes, respectively, and the axes are rotated until each histogram includes characteristics of a line. Also disclosed is a process of detecting a vehicle in an adjacent lane, systems for performing the aforementioned processes, systems for identifying an object and an input signal, and an interface between an image processing system and a controller.